A MODEL SEWAGE TREATMENT PLANT

FOR

WASTE TREATABILITY STUDIES

DIVISION OF RESEARCH

ONTARIO WATER RESOURCES COMMISSION

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SUMMARY

A model sewage treatment plant to be used in determining the biodegradability of industrial wastes has been developed by the Division of Research, Ontario Water Resources Commission. It is the purpose of this paper to describe the design and operating principles of the unit and to indicate when and how it can be used to advantage.

The model plant works on the same principles as the High Rate - Combined Tank modification of the Activated Sludge process[1], and very closely duplicates the activated sludge process as it is a continuous flow system employing sludge return and sludge wasting facilities.

This plant is most suitable for use in conjunction with a respiration cell to determine the optimum operating characteristics of a full scale plant.

[1] Black, S. A., "Evaluation of the High Rate - Combined Tank Activated Sludge Process", OWRC Research Publication No. 17.

1.0 INTRODUCTION

Many industrial wastes contain materials which may exert inhibitory effects on the microorganisms ordinarily found in biological stabilization systems. As soon as biological treatment of a waste is contemplated it is desirable to know whether or not any of its constituents are inhibitory to bacterial growth and, if so, the nature and extent of these effects. The accurate evaluation of the treatability of a given waste requires the determination of two factors: (1) the ability of microorganisms to degrade the waste constituents, and (2) the optimum operating conditions under which this degradation takes place.

Whether or not the waste is amenable to biological stabilization may be determined by oxygen utilization rate tests using a respiration cell. The activity of the micro-organisms in the system is reflected in the rate at which oxygen is being utilized. Lamb[2] has described a suitable apparatus and procedure to be used in such a determination. A modification of his respiration cell, made up from standard laboratory glassware, is shown in Figure 1. This cell has

[2]Lamb, J. C., "A Technique for Evaluating the Biological Treatability of Industrial Wastes", Proceedings - Thirteenth SMIWC - 1964.

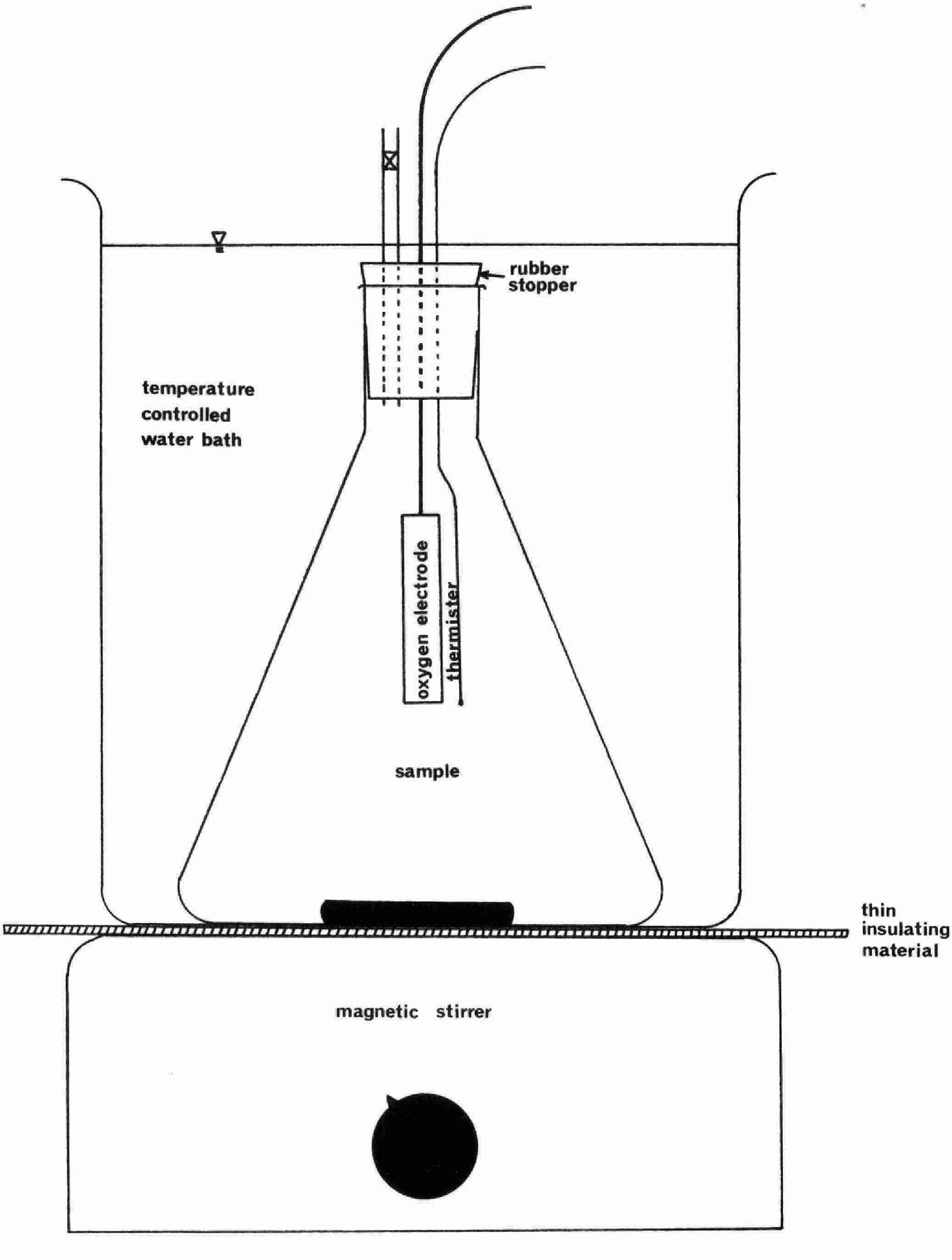

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Figure 1

Respiration Cell

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been proven to be adequate for measuring oxygen utilization rates in many Division of Research studies.

Once the biodegradability of the waste is established the waste may then be introduced into a biological treatment system to determine such design requirements as optimum retention, optimum loading, aeration requirements, etc. If optimum design considerations can be determined in the laboratory much time and money may be saved in designing further pilot studies.

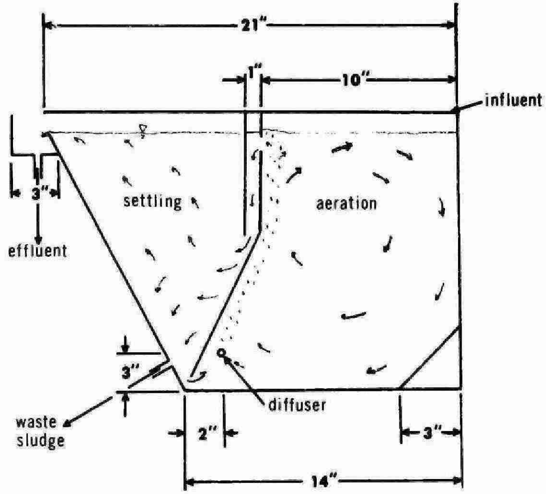
Because of the importance that model plant studies may have in evaluating the treatability of a given waste, it was decided that a plant of simple design and operation was required. A model plant was needed which would duplicate the activated sludge process, employing continuous feed, automatic sludge return and sludge wasting facilities. Research led to the fabrication of the model sewage treatment plant described herein.

2.0 PLANT DESCRIPTION

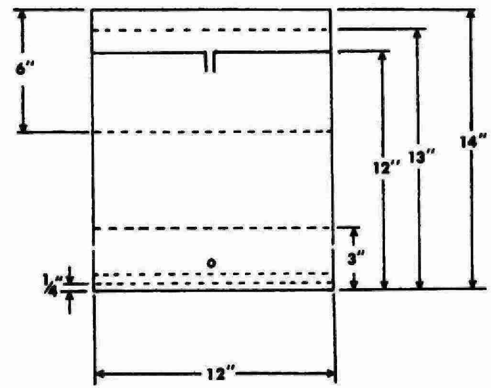
Several modifications of plant design were made before the final working model was achieved. Figure 2 presents views and dimensions of the final model. Figure 3 is a photograph of the complete setup and Figure 4 demonstrates the plant assembly.

The first plant was constructed of 1/8" double diamond glass held together with glue. By working with this plant it was found that glass was undesirable as a construction material because it was too difficult to modify with holes, etc.

The final plant was constructed with side walls of 3/8" acrylic, and end and baffle pieces of 1/4" acrylic. Depending upon the size of the plant, it was found that the side walls had to be relatively thick to prevent bowing when filled with water. Acrylic pieces, if cut smoothly, may be permanently bonded with chloroform and they may be drilled quite simply. The baffles separating the aeration and settling sections must be made adjustable to permit adequate control of the sludge return rate.



Side View



End View

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Figure 2

Model Sewage Treatment Plant

Scale: 1" = 6"   August, 1967

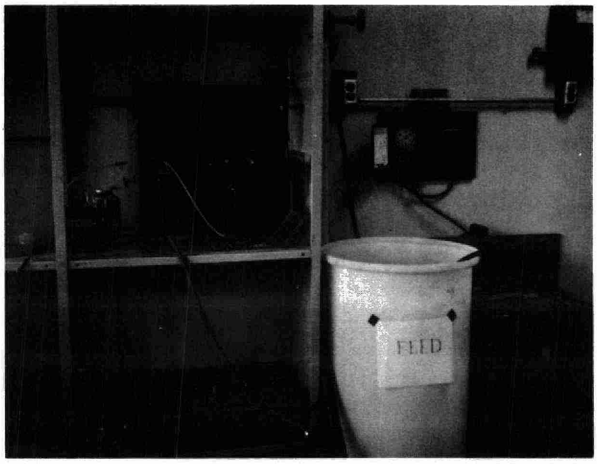

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Figure 3

Model Plant and Ancillary Equipment

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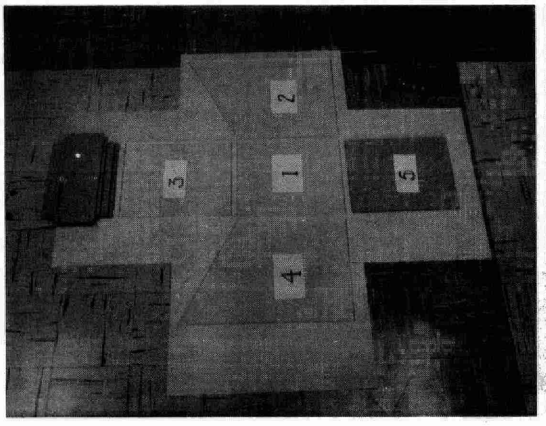

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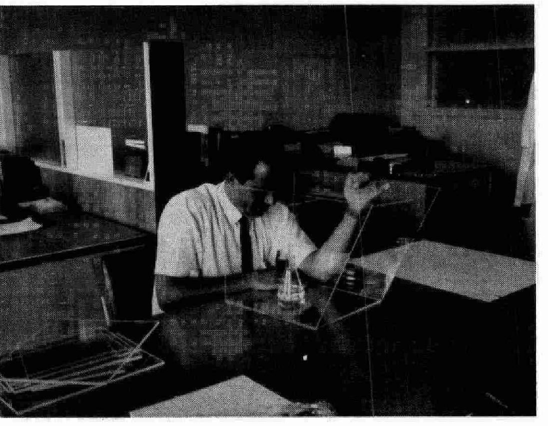

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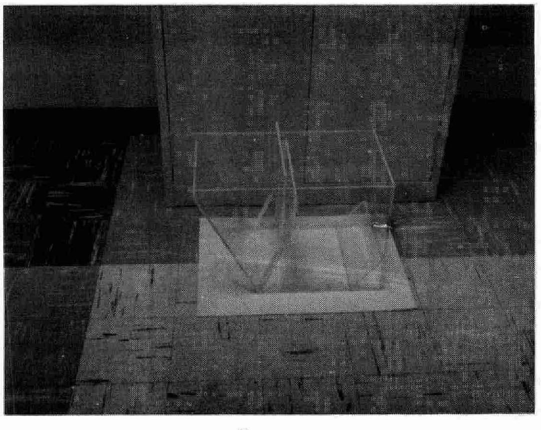

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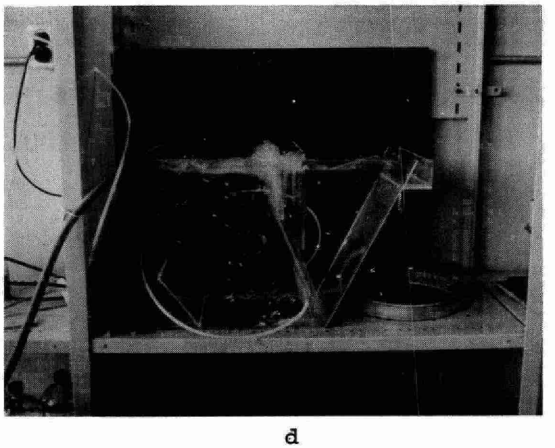

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Figure 4

Assembly of Model Plant

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Aeration is provided by a diffuser running the width of the tank at the position indicated in the diagram. The diffuser used in the Research studies was made by drilling small holes in a piece of 1/4" OD polyethylene tubing. The size of the holes in the diffuser may be a critical factor in determining the relationship between induced circulation, sludge return rate and oxygen transfer.

3.0 PLANT OPERATION

The model sewage treatment plant operates as a continuous flow, high rate of sludge return, combined tank, activated sludge plant. The performance of this model plant may be expected to be duplicated in a full scale activated sludge plant.

3.1 Feed

A convenient method of simulating continuous feed conditions may be adopted by use of a small pump, a cycle timer and a time delay relay. A fresh supply of waste to be studied is kept in a small holding tank and by use of the timers the pump may be set to feed the plant at any desired frequency and duration. Feed enters the plant as indicated in Figure 1 and may be distributed over the width of the plant by a weir system, however, in this size of plant point injection is generally adequate because of the rapid mixing characteristics of the aeration tank.

3.2 Aeration

Aeration is provided for by the polyethylene diffuser with the rate of oxygen transfer determined by the volume of air supplied and by the size of the holes in the

tubing. Since these two factors also determine the mixing characteristics of the aeration tank and the sludge return rate some trial and error may be necessary in arriving at optimum conditions. (1/32" holes at 1/4" centers have been found to be effective.)

Overflow from the aeration to the settling section is accomplished through an adjustable slot in the baffling system as shown in Figure 1. The air distribution system and the sloping side of the aeration zone raise the water level near the opening linking the aeration and settling zones and makes it possible to transfer up to four or five times the flow entering the plant.

3.3 Settling

Settling is accomplished in the V-shaped zone adjacent to the aeration section. Mixed liquor enters the settling section through the adjustable slot in the aeration wall and is immediately deflected downwards by a baffle. The liquid is introduced to the settling section at a point below the surface of the sludge layer which acts as a filter to the rising supernatant. Also at this point there is a downward pull due to the hydraulic effects of sludge return which greatly enhances settling.

3.4 Sludge Return and Wasting

Sludge is returned through the adjustable opening at the bottom of the settling tank and is effected through the differences in liquid densities and levels in the aeration and settling tanks and due to the location of the diffuser and its resultant hydraulic effects.

Sludge may be wasted through a port in the side of the settling tank wall. This may be done manually or by use of a solenoid valve and timer.

4.0 CONDUCTING A WASTE TREATABILITY STUDY

Accurate evaluation of the treatability of a given waste may require extensive laboratory studies. However, these studies are relatively inexpensive as compared to elaborate field pilot plant trials and yet, if carried out adequately, they may replace such pilot studies entirely. Two questions of prime importance in such laboratory investigations concern (a) the ability of microorganisms to degrade the waste constituents and (b) the optimum operational criteria, such as rate of aeration, retention time, design loading, etc. to be adopted by the treatment plant.

Whether or not the waste is biologically degradable may be determined by the use of a dissolved oxygen probe and a respiration cell. Once the biodegradability of the waste is established the waste may then be fed into the model sewage treatment plant to determine operating variables.

The variables to be determined using the model plant will generally include loading, retention time and rate of aeration. The importance of each of these variables is reflected in oxygen utilization rate of the sludge, settle-ability of mixed liquor, volume of sludge to be wasted and effluent quality.

The plant is started up by filling the aeration and settling sections about three-quarters full of activated sludge from an operating sewage treatment plant. The waste to be studied is then fed in at a rate to give approximately 24 hours retention in the aeration section until the micro-organisms become acclimatized to the waste. When working with very strong (high BOD) wastes it may be necessary or desirable to dilute the waste with domestic sewage, especially if treatment of the waste in a municipal sewage plant is anticipated.

The bacteria generally become acclimatized within one week. Whether or not acclimatization has been reached may be determined by the oxygen utilization rate of the mixed liquor as determined in a respiration cell.

Once the bacteria have become acclimatized to the waste, the effect of changing various operating variables may be determined.

In order that stabilization of the waste may proceed effectively a highly active sludge must develop and this sludge must settle quite readily in the settling tank. Thus

the two main factors to be determined in establishing the effectiveness of the design and operating criteria are the activity of the biological sludge as determined by the oxygen utilization rates of the aeration mixed liquor and the settling characteristics of the sludge in the settling tank. The effect of loading, aeration, retention time and other operating variables may be established by conducting the above two observations. Optimum values of each may be determined and used for future pilot studies or used directly in the design of the actual treatment facility.

The importance of obtaining a representative sample of waste for this study cannot be over-emphasized. Since the volume of waste handled and the volume of mixed liquor and bacteria are so small, any shock loads of toxic materials may greatly upset the model plant even though their effects may be negligible in a full scale plant.

If such a model waste treatability study is carried out conscientiously it should effect a great saving in time and money in designing the full scale treatment facility.